MachineLibrary™ – Broken Rotor Bar and Motor Malfunctions

All rotating equipment is susceptible to machine malfunctions such as unbalance, misalignment, fluid-induced instability or rolling element bearing defects, rub, and shaft crack. In addition to these, differences between steam turbines, gas turbines, generators, compressors, pumps, motors, and gearboxes mean that each machine type can experience additional malfunctions which are unique to its design and construction.

Bently Nevada's comprehensive multimedia training CD-ROM, MachineLibrary™, newly expanded with Release 2, is an excellent desktop resource for the fundamentals of machine malfunctions. The following summary of an excerpt from the Induction Motor Malfunctions movie illustrates how MachineLibrary uses powerful graphics, along with narration and text, to convey the essential concepts required to recognize these malfunctions.

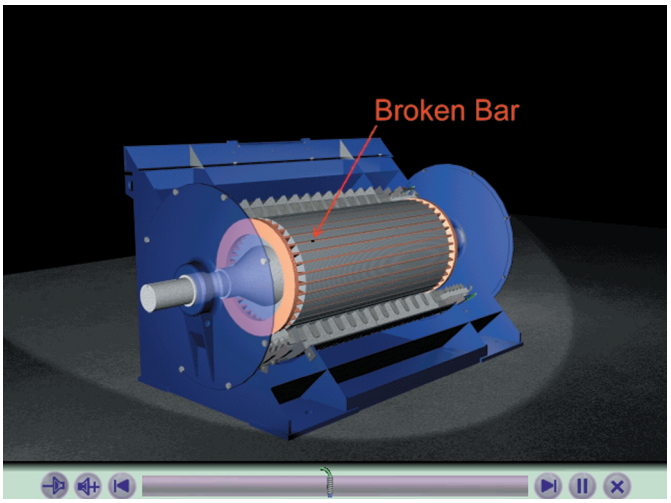

Figure 1 – Diagonal cross section of an induction motor shows how the copper rotor bars welded to the two end-rings form the rotor "squirrel cage." Electrical current induced by the stator field flows through the bars and end rings of the squirrel cage to produce the torque output of the motor. Thus, broken bars prevent current flow, which then degrades motor performance and can lead to motor malfunction.

Induction Motor Malfunctions movie (Broken Rotor Bar)

The diagonal cross section of the induction motor shows how the "squirrel cage" of the rotor is comprised of copper bars welded to end-rings (Figure 1). Electrical current, induced by the stator field, flows through these bars to produce a magnetic force that creates the desired torque. Bars that break or separate from the end-rings prevent current flow, which can impair motor performance and lead to motor malfunction.

The absence of current flow through a broken bar results in a region that is cooler than the rest of the rotor (Figure 2 left, in blue). Also, the lack of current means there is no magnetic field and its resulting attraction force, denoted by the absence of yellow flux arrows around the broken bar (Figure 2 right). These two effects combine to cause the rotor to bow away from the broken bar. The bow results in an unbalance force and an accompanying 1X vibration component.

In addition to unbalance, there is another force that acts on the rotor every time the high flux zone of the stator field crosses the region of tight air gap, 180° opposite the broken bar. The response from this combination of forces is a 1X vibration component that is modulated by a beat frequency equal to the number of poles times the slip frequency. Two tests are helpful in detecting a broken rotor bar. If the beat frequency changes in response to a load change or disappears when the motor power is cut, then a broken rotor bar may be the source of high vibration.

This is only a small sampling of what MachineLibrary has to offer. If you would like to learn more, please refer to the Fourth Quarter 1999 *ORBIT* article, "A New Version of MachineLibrary Multimedia Training Package is Now Available", pp. 66-67, or visit the MachineLibrary™ page at our website, www.bently.com.

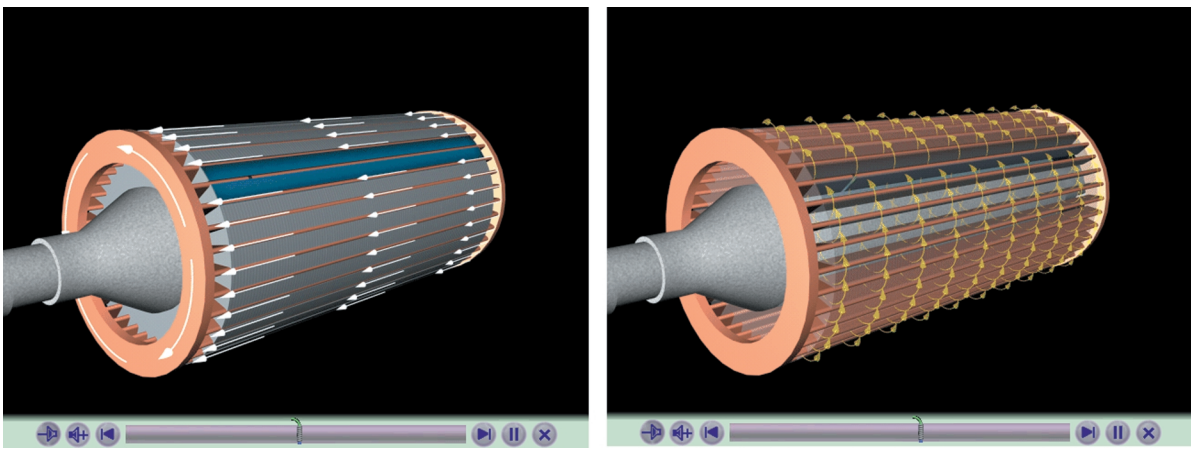

Figure 2 – The rotor develops a cooler region due to the absence of current flow in the broken bar (left, in blue). In addition, there is no magnetic flux and attraction force around the broken bar (right, denoted by yellow arrows). The combined effect is a rotor bow and an accompanying unbalance force. In addition, tight air gap opposite the broken bar contributes an additional force which modulates the 1X unbalance force at a rate equal to the number of poles times the slip frequency.